FRDA Memo

August 1988 Replaces FRDA Memo No. 004 No. 049

Planting Stock Improvement Research Update

INTRODUCTION

The Canada-British Columbia Forest Resource Development Agreement, 1985 - 1990, has committed $300 million to reforestation of backlog NSR and intensive silviculture. The Extension, Demonstration, Research and Development (E,D,R & D) sub-program of FRDA has identified the need for planting stock improvement studies, to meet the need for the high quality stock that is required for the severe conditions encountered in the reforesting of many backlog sites[1].

New opportunities in nursery-related E,D,R & D are considered annually, with guidance on priority areas being provided through the Nursery Technical Committee. Nursery projects are implemented and supported under the auspices of the FRDA Technical Advisory Committees (TAC): CTAC - coastal, NITAC - northern interior, and SITAC - southern interior and the federal direct delivery program.

Summaries of progress to March 31, 1988 and initiatives undertaken in fiscal year 1988/89 follow. The first digit of the project numbers refers to the TAC under whose program these projects are being funded (1 = NITAC; 2 = CTAC; 3 = SITAC). Project number commencing with "F" are being funded and directed by the FRDA federal direct delivery program. Addresses for project leaders and agency contacts are listed at the end of this memo.

PROPAGATION – SEED

Project 2.41: *Improving dormancy release and seed vigour of Abies lasiocarpa*

Project Leader: C. Leadem

BCFS Contact: C. Leadem

Objectives:

1. to obtain baseline data on the growth and development of *A. lasiocarpa* seedlings using a variety of physiological assessment methods (biochemical, cytological, morphological); and
2. to improve germination, seedling vigour and stock quality by optimizing environmental and growth parameters during the initial growth period.

Progress to Date:

Efforts to date have focussed on:

- the effects of moisture content and control during stratification;
- determination of the optimum treatment for breaking dormancy;
- measurement of respiration during stratification and germination;

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- development and refinement of techniques for extraction and quantification of protein contents of seeds, and determination of protein content during stratification and germination; and
- examination of the effects of seed source on stratification, moisture content, respiration and storage protein content,

Data were summarized and presented to the 8th Annual Forestry/Agriculture Colloquium at the University of Victoria during March, 1988. Results of the study are summarized in FRDA Research Memo No. 040. Another presentation will be made during the Tenth North American Forest Biology Workshop in Vancouver during July, 1988 and at the annual meeting of the Forest Nursery Association of B.C. at Vernon in August, 1988.

Project 3.58: *Survey of seed lots to which the IDS seed sorting method may apply*

Project Leader: D.G.W. Edwards

BCFS Contact: C. Leadem

[1] 5 Year Plan: Extension, Demonstration, Research and Development Sub-Program. Backlog Reforestation Program. May, 1986.

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

Canada BC

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Propagation – Seed – Cont.

Objectives:

Determine which seed lots that are in storage at the Surrey Seed Centre can be beneficially re-processed with the IDS method (Incubation, Drying, Separation).

Progress to Date:

Seed withdrawal was arranged with the Seed Centre and 40 lots have been delivered to the contractor, Canadian Pacific Forest Products Ltd. IDS sorting and germination testing are underway.

Expected Benefits:

It is expected that if IDS can be successfully applied to seed of B.C. conifers, seed and nursery costs will be significantly reduced as a result of using less seed and a decrease in multiple seeding and thinning.

PROPAGATION – ROOTED CUTTINGS

Project 1.14: *Development of a system for the large scale propagation of genetically improved interior spruce*

Project Leader: J. Russell

BCFS Contact: J. Russell

Objectives:

1. develop techniques for the large scale production of rooted cuttings of genetically improved interior spruce;
2. compare the field performance of rooted cuttings to seedlings; and
3. transfer the developed cultural regime to commercial growers.

Progress to Date:

The required greenhouse environmental control system was installed and is operating smoothly. Propagation techniques for the production of rooted cuttings (stecklings) from juvenile, genetically superior seedlings (cutting donors) has been developed. The cultural regime includes extending the photoperiod, increasing light intensity, and hedging to produce many stecklings to make the process economical. The emphasis in current work is to refine the technique and make it more economical. Steckling field trials are underway in the Prince George area.

Posters have been prepared for the Northern Silviculture Committee meeting in Prince George and the Forest Nursery Association Annual Meeting at Vernon in August 1988. A FRDA Research Memo (No. 017) is available.

Expected Benefits:

It is expected that the work will lead to an effective technique for the mass propagation of genetically improved stock.

Project 2.40: *Stock quality improvement of yellow cedar*

Project Leaders: J. Russell and S. Grossnickle

BCFS Contact: J. Russell

Objectives:

1. examine the physiological and morphological attributes of yellow cedar seedlings and rooted cuttings, associated with various nursery cultural practices, during nursery development and after outplanting; and
2. develop a cutting donor system and nursery regime to provide yellow cedar rooted cuttings of a high quality on a sustained basis.

Progress to Date:

The comparative water relations in seedlings and cuttings, and moisture stress and photosynthesis in cuttings of different ages were studied by B.C. Research. Activities by staff of the Ministry of Forests included studies on the effects of cutting hedge height on rooting, rooting improvement trials, and planting trials to demonstrate the effects of different levels of cutting maturation. Additional work being done in 1988/89 includes study of seasonal changes in physiological response, root initiation and development, ecophysiological effects of hedging on donor stock, and stock quality assessment.

Some of the results of this project will be reported at the Tenth North American Forest Biology Workshop in Vancouver during July, 1988.

Expected Benefits:

An effective program of stock quality improvement of yellow cedar seedlings from rooted cuttings.

PROPAGATION – TISSUE CULTURE

Project F52-41-110: *In Vitro clonal production and evaluation of coniferous propagules for reforestation*

Project Leader: L. Clay

CFS Contacts: E. White and R. Sturrock

Objectives:

1. produce, in a pilot tissue culture project, clonal propagules of yellow cedar suitable for operational planting;
2. evaluate the quality of yellow cedar micropropagules;
3. establish demonstration plots of yellow cedar micropropagules; and
4. continue research on micro propagation techniques of yellow cedar, Douglas-fir and white spruce.

Propagation – Tissue Culture – Cont.

Progress to Date:

Sixteen fully acclimatized micropropagules were field-planted, together with four rooted cuttings. Two thousand plantlets of yellow cedar were transferred to soil, together with 2500 rooted cuttings of the same clones. Equipment malfunctioning and cultural problems caused severe damage to the unestablished propagules. Ten clones of micropropagules from Seedlot 9777 and 100 seedlings from the same seedlot are being raised for a demonstration project.

In excess of 200 potted yellow cedar micropropagules and rooted cuttings are being maintained in the contractor's greenhouse as future source and demonstration plants.

Work on other target species include over 1000 tubes and jars of Douglas-fir and white spruce culture growing under various experimental conditions. In view of the interest in the production of weevil resistant Sitka spruce propagules, some work on micropropagation of this species has recently been undertaken.

Expected Benefits:

Potential development of micropropagation by tissue culture for mass propagation of genetically superior conifer material.

NURSERY CULTURE

Project 1.36: *The use of photoperiod to induce dormancy and terminal bud formation*

Project Leaders: C.D.B. Hawkins and D. Draper

BCFS Contact: C.D.B. Hawkins

Objectives:

1. demonstrate the effectiveness of photoperiodic induction of budset in spruce by testing night length, treatment duration and provenances;
2. evaluate treatment effects on various morphological and physiological characteristics; and
3. evaluate treatment effects upon first-year farm-field outplanting performance.

Progress to date:

Blackout systems were installed and integrated with the greenhouse environmental controller in spring, 1988. Stock for the treatments was sown in mid-March and SD treatments were initiated in July, 1988. Measurements will include seedling height, root collar diameter, and shoot and root mass, bud phenology and morphology, frost hardiness testing, dormancy release index and, if the equipment is available, variable fluorescence. A poster to describe the early part of the study and the effects of SD on bud phenology is being prepared for the Forest Nursery Association of B.C. Annual Meeting, at Vernon, B.C. in August, 1988.

Expected Benefits:

Development of a nursery cultural regime for nurseries at northern latitudes that will facilitate height growth control through short day treatments, without the need to resort to regimes that incorporate severe stress.

Project 1.43: *Cultural regimes for Abies lasiocarpa*

Project Leader: A.M. Eastham

BCFS Contact: A.M. Eastham

Objective:

Develop growing regimes for 1+0 and 2+0 container stock of *Abies lasiocarpa*

Progress to Date:

Seeds from a northern provenance near Stewart, B.C. were sown in styroblocks at the Cowichan Lake Research Station in March, 1988 for a two-year study. The principal treatment concerns the presence or absence of shade. Both light quality and light levels will be examined. The response to light levels could reflect the effect of temperature differences associated with difference light intensities .The study will also examine the response to application of growth hormones $GA_{4/7}$ and BA. All experimental treatments will be evaluated on the basis of periodic measurement of morphological growth parameters and anatomical examinations of buds. Three northern nurseries, Summit Nursery at Telkwa, Thornhill Nursery at Terrace and Woodmere Nursery at Telkwa are participating in the study.

Expected Benefits:

It is hoped that the study will lead to development of nursery cultural schedules that will prevent premature budset and repeated budsets that have characterized production of the species to date, and facilitate production of reasonably sized stock.

Project 1.45: *Examination and development of alternative growing media for production of conifer seedlings in containers*

Project Leader: R.K. Scagel

BCFS Contact: E. Van Eerden

Objectives:

1. examine the physical and chemical properties of various peat-based container growing media; and
2. develop guidelines for alternative growing media.

Progress to Date:

The principal investigator, in collaboration with Soil Con Laboratories, has conducted a survey of the various growing media currently in use in the industry. The media collected will be characterized on the basis of physical and chemical laboratory testing. The results of this survey will assist in de-

veloping alternative media during the fall of 1988. Physical and chemical evaluation of these latter media will be used to select several promising growing media for growth tests at Hybrid Nurseries Ltd. during 1989.

Growth responses to various media characteristics will be evaluated on the basis of seedling growth parameters, root morphology, health and vigour, and tissue nutrient content. The study will be completed at the conclusion of the 1989/90 growing season.

Expected Benefits:

It is expected that the study will lead to development of and recommendations for container growing media specifications.

Project 2.38: *Evaluation of winterization regimes to improve culture, storability and performance of container seedlings of western redcedar*

Project Leader: D. de Yoe

BCFS Contact: R. van den Driessche

Objectives:

Identify environmental cues that affect seedling morphology and stress resistance by:

1. monitoring and describing the growth pattern from initiation of first leaves until dormancy;
2. determining the effect of photoperiod/moisture regimes, including time and duration of application, upon seedling morphology and development of dormancy, cold hardiness, and storability; and
3. monitoring physiological status during cold storage.

Progress to Date:

Constraints imposed by operational production limited the study to observation of the single effect of decreased photoperiod and the combined effects of short day/drought stress.

Growth followed a standard sigmoid curve.

With the exception of the 2-week treatment in mid-July, combination of short day (SD) and drought stress (DR) significantly reduced shoot length and dry weight.

New leaf initiation slowed after mid-August. It appeared that SD rather than DR reduced leaf numbers, but the effect was not large. It also appeared that with the exception of the 2-week treatment in mid-July, all SD/DR combinations reduced root collar diameter. Root dry weight was not affected by SD alone, but SD/DR in combination retarded gains in root dry weight, especially for the 4-week treatment.

No differences in cold hardiness appeared to be associated with timing or duration of SD treatments. Seedlings subjected to 1 month of cold storage after lifting in mid-December showed less winter damage.

Expected Benefits:

Development of nursery cultural schedules and winterizing regimes that will minimize the risk of serious morphological damage or physiological disturbance.

Project 2.39: *Growth, nutrition and outplant performance of containerized western redcedar seedlings grown under exponentially increased nutrient additions*

Project Leader: J.W. Kumie

BCFS Contact: R. van den Driessche

Objectives:

Produce a "better" quality seedling and increase fertilizer-use efficiency by assessing the nutritional needs of western redcedar container seedlings by comparing the effects on growth, tissue nutrient content and growing medium fertility of conventional nutritional regimes with "steady state" nutrition (concentrations that increase exponentially during the exponential growth period).

Progress to Date:

Due to problems with fertilizer applications, the project was cancelled for 1987/88. With some modifications, the project is being repeated in 1988/89.

Expected Benefits:

Development of nursery cultural regimes that are conducive to production of western redcedar seedlings with the morphological and physiological attributes that match site requirements and permit safe overwintering and/or cold storage.

Project 3.17: *Optimal seedling espacement for container-grown Interior spruce*

Project Leader: D. Simpson

BCFS Contact: D. Simpson

Objective:

Determine the effects of espacement (seedlings/m^2) and cell dimension (diameter:depth) on growth of interior spruce seedlings growing in containers with a volume of 80 to 100 ml.

Progress to Date:

Fourteen different container configurations were examined during an overwinter experiment at Kalamalka Research Station and Seed Orchard. Early indications are that a spacing of 600-700 seedlings/m^2 for containers with a volume of 80 to 100 ml is the optimum spacing for producing well-balanced and sturdy seedlings of about 20 cm in height and 4 mm in root-collar diameter. The experiment will be repeated in 1988/89 during the normal growing season and will include field testing. Results will be presented as a poster to the

annual meeting of the Forest Nursery Association of B.C. at Vernon in August, 1988 and the I.U.F.R.O. stock quality meeting in York, England in September, 1988.

Expected Benefits:

It is anticipated that the results of the study will enable nurserymen to manipulate seedling size without significantly affecting seedling physiological characteristics.

Project 3.18: *Daylength and drought effects on shoot and root growth of container-grown Interior Douglas-fir*

Project Leader: D. Simpson

BCFS Contact: D. Simpson

Objective:

Determine the effects of daylength reduction and drought on seedling morphology and physiology of interior Douglas-fir.

Progress to Date:

A study was initiated in 1986/87 to examine the effects on seedling growth of no drought, cyclic drought, continuous drought and long nights (short days) with no drought. Improvements in equipment were made during 1987/88, in anticipation of a repeat experiment that is planned for 1988/89. The effects of the treatment will be examined on the basis of shoot, root and resting bud development, bud dormancy, tissue nutrient content, cold hardiness and root growth capacity. Data collection and analysis will be completed and a report on the study will be prepared during 1988/89.

Expected Benefits:

The use of non-stress regimes to induce bud set and termination of shoot growth is expected to benefit root growth and seedling quality in general and, therefore, field performance.

Project 3.43: *Use of fog misting to improve root quality of container-grown seedlings*

Project Leader: G. Hunt

BCFS Contact: D. Simpson

Objective:

Determine if misting can be used to decrease the frequency of saturation watering and thereby improve growing medium aeration without affecting seedling root growth.

Progress to Date:

Required equipment was installed and a limited trial was carried out during 1987/88. The limited extent of the trial precluded attainment of the objectives. The trial will be repeated and a final project report will be prepared during 1988/89.

Expected Benefits:

It is anticipated that periodic misting, and the potential reduction in the rate of water loss due to misting, will permit less frequent saturation watering, and thereby improve the aeration of the growing medium and enhance root growth and quality.

Project F52-41-005: *Dieback of container-grown Douglas-fir seedlings. Phase 1*

Project Leaders: S. Barnes

CFS Contacts: J. Sutherland and R. Sturrock

Objectives:

Determine the factors causing dieback in container-grown Douglas-fir seedlings by studying the effects of:

1. growing medium composition and sowing date on the incidence of dieback;
2. excessive slow release fertilization on dieback incidence; and
3. peat dilution on dieback incidence.

Progress to Date:

Investigations revealed that peat source, perlite, vermiculite, and slow release fertilizer had no significant impact on the incidence of dieback. The incidence of dieback appeared to increase with hot sunny weather. Temperature alone, however, could not explain the high block-to-block variability which was evident in dieback incidence. The major initial impact of dieback was on root and not needle growth. Nutrient concentrations were *not* indicative of ammonium or aluminum toxicities, aerobic growing medium conditions, or insufficient transport of calcium or boron to needle tips. A complex of *Pythium* species was consistently isolated from the roots of dieback seedlings. Dieback was significantly reduced by sterilizing the growing medium. The effectiveness of sterilization decreased at high growing-medium temperatures. The study results suggest that the presence of *Pythium* coinciding with unfavourable cultural regimes, such as high medium temperatures and imbalanced ammonium-to-nitrate ration, causes dieback. Further research is being conducted to confirm this conclusion. A detailed report has been prepared and submitted by the contractor, Canadian Pacific Forest Products Ltd..

Expected Benefits:

It is expected that research on this topic will provide an improved understanding of the needle dieback problem that has plagued container-grown Douglas-fir.

Project F52-41-007: *Dieback of container-grown Douglas-fir seedlings: Associated microclimate*

Project Leader: M.J. Peterson

CFS Contacts: J. Sutherland and R. Sturrock

Objective:

Evaluate the role of growing medium temperature on Douglas-fir needle tip dieback.

Progress to Date:

Results of the study suggest that high media temperatures may significantly contribute to phenomena such as Douglas-fir needle tip dieback. Recommendations for reducing the risk of high media temperature damage to conifer seedlings include:

- use a peat with good water absorption and retention characteristics;
- maintain moisture levels in containers as high as possible to reduce the risk of extreme soil temperatures while still minimizing the risk of damping-off fungi;
- avoid using a dark-coloured grit cover (lighter granite-type grit will reflect more incoming solar radiation, thus promoting a lower soil temperature); and
- use of the equation: Soil temperature = 1.4 x ambient (°C) - 5.8°C provides an estimate of the soil temperature likely to be reached within 15 minutes. The rule-of-thumb: soil temperature = 1.25 ambient temperature, may also be used within the 30-40° C air temperature range. If excessively high temperatures are predicted, compensating measures such as watering or using shade cloth should be immediately implemented where possible.

The study has been completed and a detailed FRDA report (035) has been prepared and published. A summary of the report is contained in FRDA Research Memo No. 046.

Project F52-41-104: *Dieback of container-grown Douglas-fir seedlings. Phase 2*

Project Leaders: S. Barnes

CFS Contacts: J. Sutherland, R. Sturrock

Objective:

Determine the pathogenicity of *Pythium* isolated from dieback seedlings.

Progress to Date:

Investigation revealed that *Pythium* oospores obtained from cleared dieback roots invaded root tissue of Douglas-fir germinants *in vitro* and *in vivo* and caused dieback symptoms. Oospores isolated from inoculated dieback seedlings were similar to oospores of the original inoculum cultures. Toxins and chemical or physical properties of the medium are not major contributors to dieback. If contamination of the growing medium has occurred, dieback develops under a variety of growing conditions. Possible sources of *Pythium* inoculum in a nursery include peat, water, air-borne spores and reuse of contaminated styroblocks. Root hair damage was found in seedlings grown in reused, contaminated styroblocks. Other coniferous species did not develop dieback symptoms. This may have reflected the poor growing conditions of this experiment.

A draft report of the study results has been prepared by the contractor, Canadian Pacific Forest Products Ltd. A poster will be presented at the Forest Nursery Association of B.C. annual meeting at Vernon in August, 1988

Project F52-41-108: *Effects of low soil temperatures and styroblock design upon the root growth and seedling vigour of white spruce and lodgepole pine*

Project Leader: D. Lavender

CFS Contacts: J.T. Arnott and R. Sturrock

Objectives:

1. Determine the effects of a range of soil temperatures (3, 10 and 17°C) on root growth of white spruce and lodgepole pine;
2. Determine whether alternative container design will promote increased root growth in the upper portion of the root plug after outplanting

Progress to Date:

Experimental treatments have been applied. Root growth was greatest at the highest temperature. Root growth of lodgepole pine increased linearly with temperature, but for white spruce the increase was greater from 10 to 17°C than from 3 to 10°C. The majority of root growth occurred at the lower end of the root systems, regardless of the modifications to the design of the styroblock cavity. The experiment is being repeated to determine whether various problems with the medium and lighting adversely affected the trial results.

Expected Benefits:

Clarification of the effects of nursery factors that influence root growth after outplanting.

Miscellaneous: *Container production of Sitka – interior spruce hybrids*

Project Leader: J.H. Woods

BCFS Contact: J.H. Woods

Objectives:

Estimate the species component of 61 seedlots of spruce produced in containers under a white spruce regime (extended photoperiod), and a Sitka spruce regime (no extended photoperiod).

Progress to Date:

Multivariate analysis of the variables height, root collar diameter, shoot and dry weights, and the number of days to budset served to delineate three basic groups. These groups include seedlots that are similar to white spruce, Sitka spruce or some that are intermediate in nature. On the basis of this study, the following is recommended:

1. Seedlots from the Knight Inlet, mid-coast and outer Skeena and Nass rivers (west of Terrace), appear to be more like Sitka spruce, and should respond best to a Sitka spruce growing regime.
2. Seedlots from the following areas appear to be more like interior spruce, and should respond best to a white spruce regime:
   a. the Bulkley drainage south-east of Smithers,
   b. east of the Bulkley between Smithers and Hazelton,
   c. east of the Skeena, north of Hazelton,
   d. the upper Nass above Meziadin Lake,
3. Seedlots from the intermediate zone likely contain hybrids. When growing these seedlots, it is recommended a Sitka spruce regime be followed. However, a component of these lots may result in small seedlings and not meet culling standards. If root growth is satisfactory, culling standards should be relaxed to accept the smaller seedlings.
4. A record of the growing regime and response of all hybrid spruce seedlots be prepared by the nurseries, and held for reference at the Ministry Seed Centre.

Expected Benefits:

Identification of provenances of Interior spruce that are suitable for a white spruce or Sitka spruce growing regime.

DROUGHT

Project 2.2: *Effects of certain synthetic compounds upon the survival and growth of coniferous seedlings*

Project Leader: D. Lavender

BCFS Contact: R. van den Driessche

Objectives:

Determine if the application of DPTA, which increases growth in some agricultural crops, and Alcosorb, which retains water in a mixture of soil, will result in improved growth and survival of conifer seedlings.

Progress to Date:

Treatments were applied and data were collected. Final report will be prepared this summer.

Expected Benefits:

See statement of objectives.

Project 2.20: *Testing planting stock for drought resistance.*

Project Leader: R. van den Driessche

BCFS Contact: R. van den Driessche

Objectives:

1. examine the relative importance of drought tolerance to seedling survival; and
2. develop a method of predicting nursery stock drought tolerance from measurement of osmotic potential.

Progress to Date:

Experiments on the effects of temperature and photoperiod on osmotic potential in Douglas-fir have been completed. The experiments showed that temperature is the more important factor in maintaining a low osmotic potential. Methodology for determining tissue drought tolerance has been developed using conductivity. For 1988/89, a working plan for a study on the "effect of temperature and drought on drought resistance" has been written and is under review. In this study, seedlings of two seed sources of each of Douglas-fir and white spruce are being grown in containers to examine the effect of temperature and drought cycles during July, August and September on final drought resistance. The effects of nutrient supply and a chemical growth inhibitor are also being evaluated. The work was reported to an Agriculture and Forestry Colloquium at the University of Victoria in March, 1988.

Expected Benefits:

Because osmotic potential is measurable, the study may provide a method of measuring drought hardiness.

Project 2.21: *Water loss from leaves of planting stock*

Project Leader: J. Worrall

BCFS Contact: G. Krumlik

Objectives:

Quantify water loss from spruce plug stock and determine the role of new foliage in the overall water economy of seedlings following outplanting.

Progress to Date:

Results to date suggest that the period from bud-burst to completion of shoot growth is not particularly prone to water loss. Young leaves are water-proof and, therefore, are not involved in poor survival of spring plantings. Indications suggest that water lost from newly-planted seedlings reflects sluggishly closing stomata. It is suspected that this reflects a nursery carry-over effect, because frequent nursery irrigation precludes the need for closed stomates. This hypothesis will be tested by studying water loss from newly planted and natural seedlings near Prince George during 1988/89.

Expected Benefits:

It is expected that the study will yield an improved understanding of the role of water loss in the establishment of newly established seedlings.

Drought – Cont.

Project 3.15: *Effect of Agrobacterium rhizogenes on root development and drought avoidance in Interior Douglas-fir bareroot planting stock*

Project Leader: D. Lavender

BCFS Contact: A.H. Vyse

Objectives:

Determine if infection of the root systems of Douglas-fir seedlings by *Agrobacterium rhizogenes* increases the fibrosity of the root system and increases the ability of the treated seedlings to avoid drought.

Progress to Date:

Populations of Douglas-fir, of which the roots had been exposed for varying periods of time to cultures of the bacterium, were outplanted in the UBC forest nursery, and near Savona in the Kamloops area. The bacterium was apparently not able to colonize seedling root systems and seedlings treated with the cultures, with or without the bacterium present, made poorer growth and had lower survival than the controls. The results of the study are being prepared for journal publication, completing the project.

Expected Benefits:

The study failed to demonstrate that there was any benefit associated with this treatment.

Project 3.16: *Effects of hydrophilic polymers upon the survival and growth of lodgepole pine and Interior Douglas-fir seedlings*

Project Leader: D. Lavender

BCFS Contact: A.H. Vyse

Objectives:

1. determine if seedlings whose roots had been coated with a hydrophilic gel would demonstrate a higher survival under drought conditions; and
2. determine if the addition of small quantities of a hydrophilic gel to the rooting medium in containers would permit less frequent irrigation during the dormancy induction period and, hence, increase the efficiency of imposed drought in stimulating dormancy.

Progress to Date:

Applications of any of three hydrophilic gels failed to increase either survival or growth after planting. Overwinter damage and rodent damage greatly affected field survival.

Additions of hydrophilic gels increased the water holding capacity of the rooting medium, but did not permit lengthening of the time interval between irrigations. The results of the study are being prepared for journal publication, completing the project.

Expected Benefits:

The study failed to demonstrate that there was any benefit associated with this treatment.

SEEDLING QUALITY

Project 1.30: *The effect of post storage handling conditions on the physiology and survival of white spruce seedlings*

Project Leader: W. Binder

BCFS Contact: W. Binder

Objectives:

Investigate the effects of heating on the physiology and subsequent survival of white spruce seedlings after removal from frozen storage, by:

1. identifying the temperatures and time periods to which white spruce seedlings can be exposed without affecting survival and growth; and
2. determining to what extent physiological tests can be used to evaluate decreases in stock quality due to stress during handling.

Progress to Date:

The equipment required to complete the tests is in place, tested, and calibrated. Seedlings have been lifted (Nov. 25 - 27, 1987), stored at the Research Laboratory at -2°C. Stock was sampled for RGC, bud respiration, and frost hardiness before lifting, at lifting and during cold storage. A correlation study between bud respiration and an enzymatic test for cellular viability has been completed.

After removal from cold storage, the stock was thawed and exposed to heat as a stress treatment. Physiological measurements were taken during this period. The seedlings have been outplanted in a field at the Research Station. Field observations include measurement of RGC, soil temperatures, water potentials, frost hardiness, bud respiration, and seedling morphology. Evaluations will continue through the summer and fall of 1988.

Expected Benefits:

It is expected that the study will serve to define the level(s) of stress that can be tolerated by white spruce.

Project 1.31: *Correlation of physiological and morphological assessments in white spruce seedlings to RGC and chlorophyll fluorescence*

Project leaders: C.D.B Hawkins and D. Draper

BCFS Contact: C.D.B. Hawkins

Objectives:

1. determine changes with time in physiological and morphological characteristics of white spruce that can be attributed to nursery cultural regimes;
2. Determine the effects of physiological and morphological changes on white spruce seedling storability, RGC and subsequent growth;

Seedling Quality – Cont.

3. if available, determine the utility of a prototype portable fluorometer under operational conditions; and
4. correlate changes in variable fluorescence to changes in physiology, morphology and RGC in white spruce seedlings.

Progress to Date:

Two preliminary studies concerning the cost and effect of germination temperature and heating source, and the effect of fertilizer regime on Interior spruce nursery growth have been completed and reported in FRDA Research Memos 018 and 022, respectively. Results of the germination temperature/heating source study has already been published as an abstract in the Journal of Horticultural Science and a manuscript for a full article has been submitted to the same journal. A poster has also been prepared for the Forest Nursery Association of B.C. Annual Meeting at Vernon, B.C. in August, 1988. As a result of these two studies, germination and fertilizer regimes for seedling studies at the Red Rock Research Station have been modified, as follows:

Germination temperature:

- 20°C for 24h/day for the first five days and
- 20/11°C for the 12/12 h day/night regime for the remainder of the germination period, to encourage early control of crop growth and minimize heating costs.

Fertilizer regime:

- 20-8-20 (N:P:K) soluble fertilizer will be applied without any incorporation of slow release fertilizers in the growing medium.

To meet the objectives, other seedlings grown during 1987 were lifted and placed in freezer storage on November 3, 1987. Assessment of seedling physiology (RGC, dormancy release index, photosynthesis, respiration and fluorescence (Simon Fraser University) and morphology commenced in early December and continued through storage. The components for a fluorometer, which is to be constructed in the next fiscal year, were purchased. Outplanting for field observations started in 1987. Total seasonal plant growth will be calculated and correlated with physiological measurement, including F_v, if equipment is available.

Benefits Expected:

It is expected that the study will result in development of methodology and instrumentation that will permit operationally meaningful and repeatable physiological assessments of stock quality before and after planting.

Project 2.02 : *Relationship of root growth capacity to survival and growth*

Project Leaders: W. Binder, G. Krumlik and R. Scagel

BCFS Contacts: G. Krumlik and W. Binder

Objective:

Determine the survival and growth of coastal species relative to RGC (root growth capacity).

Progress to Date:

Results of the study indicate that RGC lacks accuracy, precision and repeatability. Mean batch RGC values showed no strong relationship to mortality or growth, and within-batch variation of root growth was highly variable. Different test environments and durations gave different rankings for the same batch. There is more of a chance of being misled at lower RGC values than at higher values. Interpretations of RGC tests for outplanting mortality and growth must also consider the variability in the test and other seedling conditions.

To date, results of the study have been reported to the Northern Growers Association at Prince George, the Okanagan Growers Association at Oliver, and the Vancouver Island Growers Association at Parksville. A presentation will also be made at the Annual Meeting of the Forest Nursery Association of B.C. at Vernon in August, 1988. Additional presentations are planned for the North American Forest Biology Workshop, SIBC and the provincial Silviculture Committees (NSC, SISCO and CSC). A final FRDA report, a report in Solutions newsletter, and journal articles will be prepared during 1988/89.

Expected Benefits:

RGC provides a point estimate of a seedling's ability to grow new roots when exposed to conditions that are favourable to root growth. Consequently, with present knowledge, the principal value of RGC tests lies in the ability to separate live and dead seedlings.

More research is planned in conjunction with other projects, including the construction of variable fluorescence instruments (see project 2.19).

Project 2.19: *Variable fluorescence induction (F_v) analysis as an indicator of tree seedling stock quality*

Project Leaders: W. Vidaver, W. Binder, R.C. Brooke and G.R. Lister

BCFS Contacts: W. Binder and C.D. Hawkins

Objectives:

Determine whether the condition of a seedling's photosynthetic system, as measured by variable chlorophyll fluorescence, provides an assessment of seedling quality:

1. in the nursery;
2. in cold storage;
3. after cold storage and prior to field planting; and
4. after field planting.

Specific subjects of interest concerning the potential of F_v for assessment of seedling physiological quality include:

Seedling Quality – Cont.

1. Nursery:
   - dormancy and frost hardiness;
   - lifting windows and storability;
   - watering regimes
2. Cold storage:
   - physiological status and change;
3. Post cold Storage:
   - before shipment to field;
   - after shipment but prior to planting;
4. After planting:
   - predictive ability with respect to performance after outplanting, including root growth, water status, photosynthetic capacity and frost injury.

Progress to Date:

Correlations between F_v and RGC, for both high and low values, have been established for white spruce on removal from cold storage. Indications are that F_v measurements can substitute for or replace RGC tests.

F_v assessment was able to detect water stress and an associated decline in carbon assimilation at temperatures of 22 to 25° C even though styro-block weights did not indicate a water deficit. Results suggest that 2+0 container stock may be at or below the required moisture threshold for most of the summer, suggesting that maximum photosynthetic capacity may never be reached. The pattern for 1+0 may be similar.

F_v studies also indicated that dormancy of a particular white spruce seedlot was initiated by mid-August and was completed by the third week of October. The F_v results agreed with the standard -18°C storability test and indicated that postponement of storage beyond the October date would result in a net carbon loss.

The F_v project also showed that physiological activity of white spruce is keyed to the season of the year but is being influenced by environmental variables. With low elevation Douglas-fir, on the other hand, physiological activity was found to be primarily dependent on environmental variables (eg. temperature and water stress).

Two prototype fluorometers have been constructed that will be applied to field studies in the coming year. Preliminary steps have been taken to produce a commercial model. Numerous papers, posters and talks on F_v have been prepared and presented, including articles in and interviews with the media and presentations to B.C. nurserymen. Various aspects of the project will be reported at the Tenth North American Forest Biology Workshop in Vancouver in July, 1988.

Expected Benefits:

Development of a non-destructive method of seedling quality assessment that facilitates continuous tracking of quality rather than discontinuous point estimates would provide nurserymen and field foresters with a critically missing tool to guide management decisions for nursery and field operations.

Project 3.9: *Interpretation of stock quality monitoring data*

Project Leaders: D. Simpson, A.H. Vyse, C. Thompson and C.G. Sutherland

BCFS Contact: D. Simpson

Objective:

Determine the relationship between pre-planting RGC (root growth capacity) and field performance of interior spruce, lodgepole pine and interior Douglas-fir.

Progress to Date:

Nursery RGC tests of various seedlots were determined prior to planting. To date, 18 test plantations have been established and two additional plantations will be established in 1988/89. Measurements at planting, 4 to 8 weeks after planting, at the end of the first growing season and after two growing seasons, have been made. Additional data will be collected during 1988/89. A report on early results of the study will be presented at the Annual Meeting of the Forest Nursery Association of B.C. at Vernon, B.C. in August, 1988.

Expected Benefits:

It is intended that the study will demonstrate the minimum levels of RGC that are required for good survival and growth on the major forest site types in the Southern Interior.

Project 3.14: *Cold hardiness of conifer roots*

Project Leader: D. Simpson

BCFS Contact: D. Simpson

Objectives:

1. evaluate several existing methods and/or develop new methods of measuring root mortality caused by low temperatures;
2. examine the seasonal development and environmental control of root hardiness; and
3. investigate the effect of temperature on the repair of non-lethal damage caused by low temperatures.

Progress to Date:

The method of root freezing that was employed was found to be unsatisfactory for detailed examination of root physiology. As a result of discussions with scientists in Sweden during a visit to that country, new equipment that will permit refinement of freezing methods and assessment of damage, has been ordered. The effects of day length and temperature on root hardiness of seedlings of white spruce, lodgepole pine and Douglas-fir have been examined. Progress reports have been presented to the 1987 annual meeting of the Forest Nursery Association of B.C. at Smithers in September, 1987, to students at a training course in Fredericton, N.B. in July, 1987, and in Research Memo no. 019, September, 1987.

Seedling Quality – Cont.

Expected Benefits:

The study is expected to provide an improved understanding of root hardiness and appropriate techniques for measuring root hardiness. In turn, this will facilitate development of nursery management regimes that will minimize or avoid the severe overwintering damage that has been experienced in the past.

Project F52-41-008: *Analytical techniques for assessing stress/injury*

Project Leader: D. de Yoe

CFS Contacts: J.T. Arnott and R. Sturrock

Objectives:

1. assess and calibrate the stress-induced volatile emission (SIVE) analysis system using three stresses: drought, freezing and rough handling;
2. develop a series of *fingerprint* traces for Douglas-fir; and
3. determine whether these fingerprints change as trees come out of dormancy or as a result of cold storage.

Progress to Date:

Most of the work to date has concentrated on equipment set-up, calibrations and testing, and development of appropriate techniques. Some preliminary experiments have been run. These trials showed that ethanol was a major indicator of stress under freeze stress conditions, and that with increasing stress, acetaldehyde also became a factor. To eliminate problems with contaminated air, seedlings with the growing medium removed from the roots are grown in a chamber where they are sprayed with a fine mist of nutrient solutions. A series of experiments have been started to check the SIVE systems against drought stress, freezing stress and physical handling stress. Production of a SIVE operating manual has been started. A report will be presented to the Tenth North American Forest Biology Workshop in Vancouver in July, 1988.

Expected Benefits:

Development of a routine stress test, employing the SIVE system.

Project F52-41-010: *Ecophysiological assessment of operational and improved seedling stock types in coastal forest regeneration programs in coastal British Columbia*

Project Leader: S. Grossnickle

CFS Contacts: J.T. Arnott and R. Whitehead

Objectives:

1. examine the physiological and morphological attributes of operational and improved stocktypes during and just after the nursery development phase;
2. examine the physiological and morphological attributes of various stocktypes of coastal conifer seedlings and make an assessment of their performance under controlled environmental conditions;
3. examine the physiological and morphological response of various stocktypes to field microclimatic conditions during the three phases of seedling establishment; and
4. link the performance of various stocktypes to nursery assessments and controlled environment conditions under field site conditions.

Progress to Date:

The first phase of this project included a series of stock quality assessment studies that examined the physiological and morphological characteristics of western redcedar and western hemlock seedlings developed under different nursery cultural regimes. The following is a list of the stock quality assessment studies which were conducted:

1. drought stress resistance;
2. influence of low root temperatures on the physiological response of various stocktypes;
3. frost hardiness;
4. pressure-volume analysis;
5. needle and root surface area;
6. photosynthetic patterns;
7. mineral nutrient analysis;
8. cuticular development;
9. starch and sugar analysis;
10. root growth capacity;*
11. morphological characteristics.*

*Conducted by the Canadian Forestry Service

All of the above stock quality assessment studies have been completed. Analysis of data and interpretation of results will be conducted over the next three to four months. The results of this stock quality assessment procedure will be presented at the Western Forest Nursery Council and Forest Nursery Association of B.C. annual meeting at Vernon, B.C. in August, 1988.

At this time no further work will be conducted on the stock quality assessment phase of this project. Future work will be directed at monitoring of western redcedar and western hemlock nursery stock in control and field reforestation site trials.

Expected Benefits:

An improved understanding of the physiological response of various operational and improved stock types of western redcedar and western hemlock to field environmental conditions.

NURSERY PEST MANAGEMENT

Project 1.6: *Efficacy and phytotoxicity of fungicides for control of Botrytis gray mould on container-grown conifer seedlings.*

Project Leaders: M.M. Glover, J. Sutherland, C. Leadem, and G. Shrimpton

BCFS Contact: G. Shrimpton

Objectives:

1. test six fungicides at three concentrations each for phytotoxicity to live tree species and their effectiveness in controlling *Botrytis*; and
2. obtain registration of these fungicides for use in B.C. nurseries.

Progress to Date:

The fungicides anilazine®, captan®, dichloran®, folpet®, iprodione®, and thiram® were tested for efficacy on container-grown seedlings of white spruce, western redcedar, western hemlock, Sitka spruce and Douglas-fir.

Growth of all species except Douglas-fir was inhibited by one or more of the fungicides. Iprodione® gave excellent *Botrytis* control on all seedling species. Anilazine® gave adequate control on all species except Douglas-fir and western redcedar. Gray mould control on western redcedar was excellent with thiram®, and good on all other species except western hemlock. Folpet® gave good control of *Botrytis* on Douglas-fir and Sitka spruce. Disease control was excellent with dichloran® on western hemlock and white spruce. Captan® provided good gray mould control on Douglas-fir. *In vitro* tolerance tests showed that all ten of the *B. cinerea* isolates used in the experiment were sensitive to iprodione® and dichloran®, and to captan® at the 2 X dosage. All isolates were tolerant to anilazine®, most were tolerant to thiram® and folpet®, and to captan® at the 0.5 X and 1 X dosage. The study has been completed and a detailed report, FRDA Report 012, is available from the sponsoring agencies. A FRDA Research Memo (039), summarizing the study, is also available.

Expected Benefits:

It is intended that the study will identify alternative fungicides to which *Botrytis* has not yet developed tolerance, and facilitate minor use registration of some of the fungicides for B.C. nurseries.

Project 1.47: *Trials with the herbicide oxyfluorfen (Goal®) and napromide (Devrinol®) and the fungicide benomyl (Benlate®) on container-grown seedlings in B.C. forest nurseries*

Project Leader: F. Williams

BCFS Contact: G. Shrimpton

Objective:

Supply the data to gain registration of napromide (Devrinol®) and the fungicide benomyl (Benlate®) for container - grown nursery stock.

Progress to Date:

Treatments are being established according to standard protocol for the chemicals in question for testing on 1+0 and 2+0 containers stock of major conifer species at Surrey Nursery. Treatment rates and frequency will vary according to the chemical being tested.

For the oxyfluorfen trial, a full report will be submitted to the National Tree Nursery Weed Control Association consistent with the Canada-wide trial to gain registration for oxyfluorfen. An abstract will also be submitted to the Expert Committee on Weeds.

A report on the napromide trial will be submitted to the Pesticide Directorate in Ottawa to gain a label extension under the Minor Use Pesticide Programme. An abstract will be submitted to the Expert Committee on Weeds.

For the benomyl trial, a report will be sent to the federal Pesticide Directorate to gain a label registration for the use of this fungicide on *Fusarium* rot in container conifer nurseries in B.C.

Expected Benefits:

It is intended that the study will lead to registration of the three chemicals being tested for use in forest nurseries in B.C.

Project 2.29: *Oxyfluorfen trials in British Columbia*

Project Leaders: G. Shrimpton and D. Trotter

BCFS Contact: D. Simpson

Objectives:

1. evaluate the tolerance of 1+0 and 2+0 bareroot Douglas-fir and lodgepole pine to various rates of oxyfluorfen application;
2. determine the degree of efficacy of the herbicide in controlling common nursery weeds in B.C.; and
3. to gain full registration for use of oxyfluorfen in forest nurseries.

Progress to Date:

The study was completed during 1987/88. Pre-emergence and prior to bud-break applications at 0.25 and .50 kg a.i./ha were found to be the most effective in terms of weed control and phytotoxicity considerations. This applied to both 1+0 and 2+0 stock of Douglas-fir and lodgepole pine. These observations are in agreement with the proposed label for oxyfluorfen. Morphological characteristics of seedlings in the selected treatments met or surpassed current B.C. standards. An ancillary and preliminary trial with oxyfluorfen for controlling weeds in container nurseries, especially liverwort and moss, showed considerable promise and the need for

further work with oxyfluorfen in container nurseries. The results have been written up in a detailed report for submission in support of a request for federal registration of the herbicide for use in forest nurseries. An additional report, aimed at the forest nursery industry, is being considered for submission to Tree Planters Notes or the Journal of Weed Science.

Expected Benefits:

If oxyfluorfen is approved for registration as a herbicide for forest nursery use, properly timed applications will significantly reduce weed control costs in forest nurseries in B.C.

Project 2.48: *Revision - Handbook "Diseases and Insect Pests in British Columbia Forest Nurseries"*

Project Leaders: J. Sutherland, G. Shrimpton and R. Sturrock

BCFS Contact: G. Shrimpton

Objective:

To revise the above handbook in accordance with current knowledge and nursery requirements.

Progress to Date:

Revision of the text has been completed. The manuscript has been reviewed and the publication is now being prepared for printing later in the year.

Expected Benefits:

It is expected that the revised handbook will provide nurserymen with an improved capability for identifying, preventing and managing pest problems.

Project F52-31-104: *Gray Mould control: Seedling canopy humidity reduction through under bench heating and styroblock aeration*

Project Leader: M. Peterson

CFS Contacts: J. Sutherland and R. Sturrock

Objective:

Investigate gray mould control on container-grown Douglas-fir seedlings by promoting rapid drying of foliage following watering.

Progress to Date:

Experiments are being conducted at the container nursery of Canadian Pacific Forest Products Ltd. and include the following treatments:

1. Drilled styroblocks with under-bench forced air heat applied following watering;
2. Drilled styroblocks with unheated under-bench forced air applied following watering; and
3. Standard configuration styroblocks with no forced air or heat applied following watering.

Seedling canopy temperature and humidity, and cavity soil temperature will be monitored throughout the growing season. Seedlings will be examined for morphological characteristics that may be associated with increased styroblock aeration. Operational container crops of Douglas-fir will be examined for gray mould.

Expected Benefits:

It is hoped that improved aeration and reduced RH within the seedling canopy will reduce the potential for gray mould infection.

Project F52-41-100: *Monitoring the greenhouse environment to predict the need for or timing of fungicide applications for control of gray mould (Botrytis cinerea) on container-grown seedlings*

Project Leader: M. Peterson

CFS Contacts: J. Sutherland and R. Sturrock

Objective:

Evaluate three fungicides currently used in gray mould protection programs for effectiveness in a post infective or curative regime with their applications scheduled on the basis of temperature and RH parameters previously found optimum for infection on horticultural crops.

Progress to Date:

Results of the study showed that post infective sprays of captan (Captan®) chlorothalonil (Bravo 500®) and benomyl (Benlate®) were no less effective than the timed production schedule. Post-infective applications, applied 48 hours after an infection period, were not as effective as those used within 24 and 36 hours. The best post infective control was obtained with Captan® and Brava 500®.

An effective dew-duration sensor is a prerequisite for more accurate prediction of gray mould infection periods prior to the implementation of an effective curative spray program.

A detailed report on the completed study has been submitted to the Canadian Forestry Service.

Expected Benefits:

Improved gray mould management in container nurseries.

MYCORRHIZAE

Project F52-41-006: *The effects of mycorrhizae fungi in coniferous nursery stock and reforestation success in Interior British Columbia*

Project Leader: G. Hunt

CFS Contacts: J. Sutherland and R. Sturrock

Objectives:

1. determine the effects of fertilization on mycorrhizae formation and growth of Interior spruce, Interior Douglas-fir and lodgepole pine;
2. compare the effects of three genera of mycorrhizae fungi on seedlings of three species in a container nursery; and
3. evaluate the effects of three genera of mycorrhizae fungi on plantation performance of container seedlings of three species.

Progress to Date:

Experimental treatments were applied, stock was lifted and cold-stored, and experimental plots were established. Data are being collected and analyzed. A related FRDA project (3.35-8) showed promising results for some of the treatments. For further information on that study, see FRDA Research Memo 029.

Expected Benefits:

It is expected that the project may serve to develop mycorrhizae inoculation regimes that will enhance plantation performance in the southern Interior of B.C.

Project F52-41-109: *Influence of soil temperature on the effectiveness of mycorrhizae in promoting white spruce seedling growth*

Project Leader: L. Husted

CFS Contact: T. Trofymow and S. Taylor

Objectives:

Examine the effects of root temperature on the growth, physiology and root development of inoculated and non-inoculated seedlings of white spruce by:

1. determining how root temperatures affect white spruce seedling root growth and colonization by northern and southern isolates of mycorrhizal fungi; and
2. comparing the tolerance of established northern and southern isolates of mycorrhizal fungi to cold and hot root temperatures.

Progress to Date:

Equipment and cultures have been obtained. Soil bioassays are in progress. The first experiment has been established. Seedlings have been grown and inoculated. A second experiment is underway and additional experiments have been described in a thesis proposal.

Expected Benefits:

It is expected that the studies will contribute to an improved understanding of the relationship between soil temperatures and mycorrhizal establishment and, ultimately, growth of white spruce.

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